

INTRODUCTION

- Listening effort: the attention and cognitive resources required for speech recognition and perception.
- Increased listening effort can leave the listener feeling "mentally exhausted"
- A dual-task paradigm provides the opportunity to objectively quantify listening effort. The primary task is a listening task and the secondary can be many different measures; a memory task, visual-tracking, tactile sensations or, a visual-reaction like the Stroop task.
- Purpose:** Derive the psychometric function of the dual task paradigm.

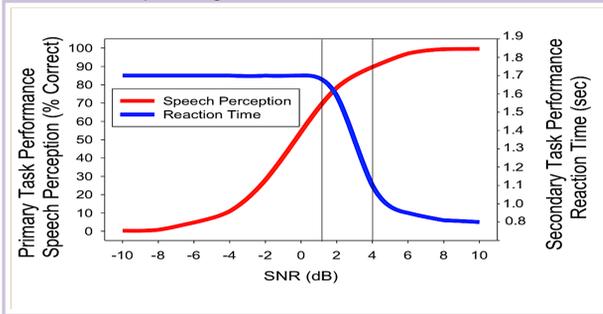


Figure 1. Hypothesis of dual-task paradigm measuring Reaction Time for secondary task and speech perception performance for the primary task.

- Hypothesis: the psychometric functions of the **primary** and **secondary** tasks are dependent on the difficulty of the signal-to-noise ratio (SNR).

METHODS

Participants

- Twenty-four normal hearing adults Ages 19-30 (mean = 23.4)
- Normal color vision, and native English speakers

Equipment

- In a sound treated booth, the stimuli were presented to subjects bilaterally through earphones.
- Participants were seated in front of a computer monitor; using a keyboard with keys labeled B, Y, G, and R.

Procedures

- Each subject's SNR50 (SNR where 50% of the words are repeated correctly) was determined using the Hearing in Noise Test (HINT)
- Subjects completed the easy and hard dual-task conditions over two visits.
- Speech signal:** 65 dB SPL for all trials
- Speech-shaped noise:** Eleven trials of 2 dB SNR intervals between -10 and +10 dB
- Following each set of sentences the listener was asked to rate their listening effort.

METHODS Cont.

Procedures Cont.

- The performance at a given SNR is computed by dividing the number of words correctly repeated by the number of target words in that HINT list.

Dual-Task Paradigm

- Primary task:** speech-recognition in noise.
- Secondary task:** Stroop test.
 - "Easy" condition: respond to the stimulus by pressing the space bar, no matter the color
 - "Hard" condition: respond to the font color, instead of the color word, by pressing a button assigned (B, Y, G and R) to a given color (Blue, Yellow, Green and Red) as quickly as possible.
- The color word and font inconsistencies require increased semantic decision-making, absorbing cognitive load from the primary task.

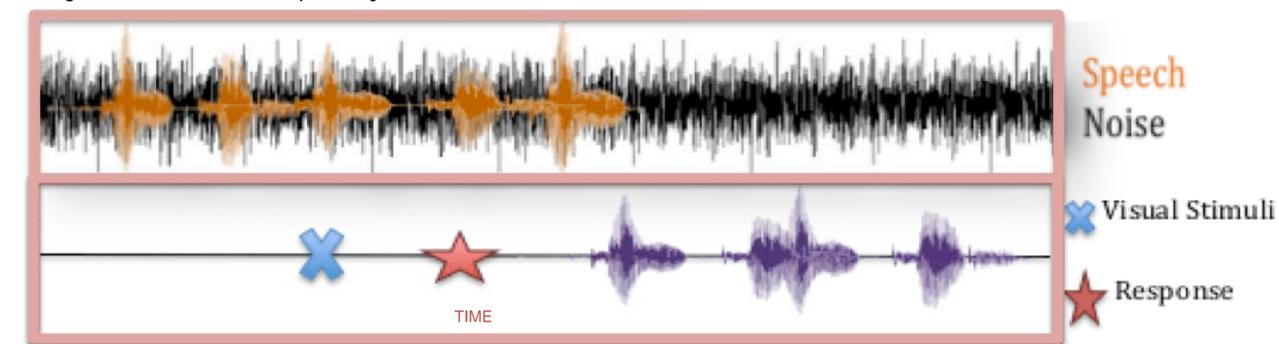


Fig 4: Speech and noise are played simultaneously with presentation of the visual stimulus at a randomized point during the sentence. The subject responds to the visual stimulus first and then repeats the sentence. The difference between the visual stimuli and the button pushing is the response time (RT).

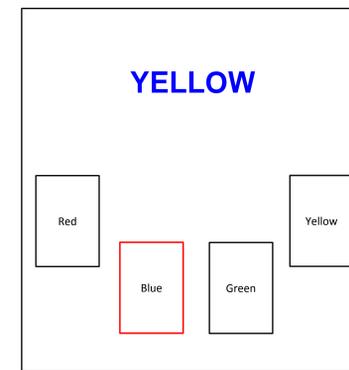


Fig 2- An example of the "Hard" condition of the Stroop Task; the participant **correctly** pressed the "B" key, choosing "Blue".

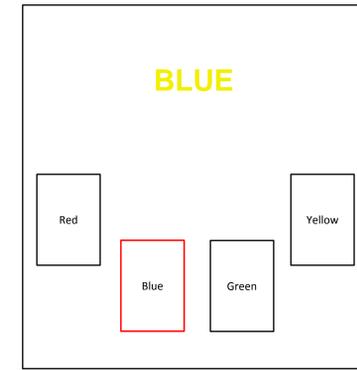


Fig 3- A common error of the "Hard" condition; the subject **incorrectly** selected "Blue"; the correct response is "Yellow".

DISCUSSION

- The results indicated that RT does not increase asymptotically at less favorable SNRs even though speech performance became worse. This contradicts the hypothesis. Instead, the psychometric functions of the secondary task were peaked. As noise level increased, the RT initially increased and then decreased with the peak falling around 0 dB SNR.
- We see a bell-shaped curve in the RT because at very difficult SNR conditions the subjects were not using much effort to understand the speech stimuli. Instead, they focused their efforts on the secondary task where they had a greater chance of success than repeating sentences with a lot of noise.
- The objective and subjective measures were similar, however the subjective measure did not have a peak at 0 dB SNR. Here, the subjects' perception of their effort was much less than what their RT suggests.

RESULTS

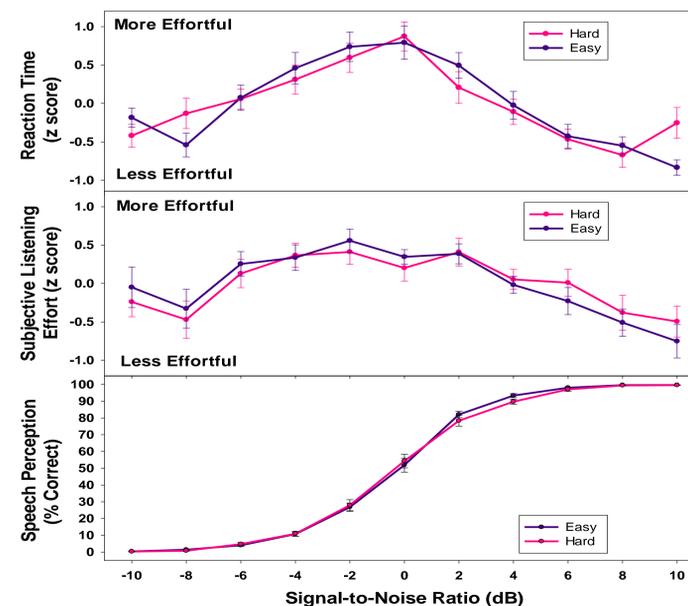


Fig 5: Reaction time (4a), subjective listening effort (4b), and speech perception (4c) as a function of SNR.

CONCLUSIONS

Previous research using dual-task paradigms has inconsistent results limiting the usefulness of dual-task paradigm to measure listening effort. Some studies show decreases in listening effort while others show increases. This research reveals the importance of selecting the correct SNR. Listening effort would increase between -4 dB and -2 dB SNR but would decrease between +2 dB and +4 dB SNR. When using a dual-task paradigm for measuring listening effort, we recommend SNR between +1 and +3 dB.

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